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ON-SITE HYBRID VEHICLE INVESTIGATION

CASE NUMBER - IN09011
LOCATION - TEXAS
VEHICLE - 2006 HONDA CIVIC HYBRID CVT
CRASH DATE - January 2009

Submitted:

May 11, 2009

Contract Number: DTNH22-07-C-00044

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
National Center for Statistics and Analysis
Washington, D.C. 20590-0003

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

Technical Report Documentation Page

1. *Report No.* IN09011	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
4. *Title and Subtitle* On-Site Hybrid Vehicle Investigation Vehicle - 2006 Honda Civic Hybrid CVT Location - Texas		5. *Report Date:* May 11, 2009 6. *Performing Organization Code*	
7. *Author(s)* Special Crash Investigations Team #2		8. *Performing Organization Report No.*	
9. *Performing Organization Name and Address* Transportation Research Center Indiana University 501 South Madison Street, Suite 105 Bloomington, Indiana 47403-2452		10. *Work Unit No. (TRAIS)* 11. *Contract or Grant No.* DTNH22-07-C-00044	
12. *Sponsoring Agency Name and Address* U.S. Department of Transportation (NVS-411) National Highway Traffic Safety Administration National Center for Statistics and Analysis Washington, D.C. 20590-0003		13. *Type of Report and Period Covered* Technical Report Crash Date: January 2009 14. *Sponsoring Agency Code*	
15. *Supplementary Notes* On-Site Hybrid Vehicle Investigation involving a 2006 Honda Civic Hybrid CVT.			
16. *Abstract* This report covers an On-Site Hybrid Vehicle Investigation that involved a 2006 Honda Civic Hybrid CVT, which departed the roadway and rolled over. The focus of this on-site investigation was the crash performance of the Honda's Nickel-Metal Hydride (NiMH) propulsion battery. The Honda was occupied by a restrained 37-year-old male driver who was traveling south on a 2-lane county roadway approaching a 90 degree right turn. The vehicle began to rotate clockwise as he was negotiating the right turn. The vehicle continued to rotate clockwise as it departed the roadway and impacted a woven wire fence. As the vehicle penetrated the fence, it rolled over left side leading 6 quarter turns and came to rest on its roof. The vehicle's NiMH battery sustained no damage or leakage. The driver was not injured.			
17. *Key Words* Hybrid vehicle Rollover Motor Vehicle Traffic Crash Injury Severity		18. *Distribution Statement* General Public	
19 *Security Classif. (of this report)* Unclassified	20. *Security Classif. (of this page)* Unclassified	21. *No. of Pages* 9	22. *Price*

Form DOT 1700.7 (8-72) Reproduction of completed page authorized

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This focus of this on-site investigation was the crash performance of the 2006 Honda Civic Hybrid's Nickel-Metal Hydride (NiMH) propulsion battery. This crash was brought to the National Highway Traffic Safety Administration's (NHTSA) attention on March 6, 2009 by an on-line search of auction yard inventories. This on-site investigation was assigned on March 26, 2009. The crash involved a 2006 Honda Civic Hybrid CVT (**Figure 1**), which departed the roadway and rolled over. The crash occurred in January, 2009, at 0630 hours, in Texas and was investigated by the Texas Department of Public Safety. This contractor inspected the Honda, crash scene, and interviewed the driver on April 3, 2009. This report is based on the police crash report, vehicle inspection, crash scene inspection, inspection of an exemplar vehicle, interview with the Honda's driver, Honda Emergency Response Guide for Hybrid Vehicles, occupant kinematic principles, and this contractor's evaluation of the evidence.

Figure 1: The damaged 2006 Honda Civic Hybrid CVT

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which the Honda was traveling was a 2-lane county roadway, which traversed in a north-south direction. The roadway curved 90 degrees to the west where the crash occurred. A woven wire fence and level farm field were present on the south side of the roadway in this area. The roadway had one travel lane in each direction and was composed of gravel. There were no pavement markings or curve warning sign and the roadway was 9.5 m (31.2 ft in width. The shoulders were composed of grass and dirt and were undefined. The speed limit was 48 km/h (30 mph). At the time of the crash the light condition was dawn, the atmospheric condition was clear, and the roadway surface was dry. There was no other traffic on the roadway and the site of the crash was rural. See the Crash Diagram on page 9 of this report.

Pre-Crash: The Honda was occupied by a restrained 37-year-old male driver. He was traveling south (**Figure 2**) down a negative 5% grade approaching a 90 degree right turn. The driver lived in the area and was familiar with the roadway. He was on his way to an airport and was in a hurry. He lost control of the vehicle while negotiating the right turn and the vehicle began to rotate clockwise. The driver stated in the interview that he steered right and applied hard braking in an attempt to avoid a crash.

Figure 2: Approach of the Honda south to the area of roadway departure in the right curve

Crash: The vehicle rotated clockwise 70 degrees from its original southerly heading as it departed

the south side of the roadway and approached the fence (**Figure 3**). The vehicle traveled 3.8 m (12.5 ft) off the roadway and the front left corner and left side plane impacted a woven wire fence in a penetrating type impact (events 1 and 2). A fence post engaged the sill and left front door (**Figure 4**) as the vehicle penetrated the fence. While this damage did not appear significant, there was sufficient engagement to crush the sill 5 cm (2 in). One of the vehicle's two left side impact sensors was located in the lower B-pillar, which was near the impact site on the sill. As a result, it is probable that the deployments of the vehicle's left front seat back-mounted side impact air bag and left side curtain air bag were triggered by this impact (event 2). As the vehicle penetrated the fence it rolled over (event 3) with the left side leading. The vehicle remained engaged with the fence and dislodged it and some of the fence posts. The dislodged fence scratched and dented the hood and punched a small hole in the hood and right portion of the windshield (event 4, **Figure 5**) during the rollover. The vehicle rolled over 6 quarter turns and came to final rest on its top in a farm field heading north (**Figure 3**).

Post-Crash: The driver unfastened his seat belt and exited the vehicle through the left front door. He went to a nearby house for help and the police were notified. They received notification of the crash at 0645 hours but did not arrive on scene until 0750 hours. The delay in the police response time was probably due to the driver being uninjured in the crash and the rural location of the crash. No other emergency personnel responded to the crash scene. The vehicle was towed from the crash scene due to damage.

ROLLOVER DISCUSSION

The Honda was not equipped with Electronic Stability Control (ESC) or a rollover side curtain air bag system. The vehicle was, however, equipped with 4-wheel anti-lock disc brakes. The NHTSA has given the vehicle a four

Figure 3: Approach of the Honda to the impact with the fence and rollover initiation; flags show tire furrow marks; original fence replaced with large fence posts; arrow shows area of final rest in the farm field

Figure 4: Damage to the left front door from a fence post

Figure 5: Damage from the rollover on the top and left side planes; arrow at bottom shows damage on the front plane from fence impact (event 1); other arrows show damage on the hood and windshield from the fence that occurred during the rollover (event 4)

star rollover rating on a five star scale and a Static Stability Factor of 1.43. A four star rating indicates that the vehicle has a 10%-20% chance of a rollover when involved in a single vehicle crash. The Static Stability Factor (SSF) is a calculation based on the vehicle's track width and height of its center of gravity. The result of the calculation is a measure of a vehicle's resistence to rollover. A higher SSF indicates a more stable vehicle. Most passenger vehicles have an SSF of 1.30 to 1.50. This vehicle model also did not tip-up in the dynamic steering maneuver test in which the test vehicle is put through a fish-hook shaped steering maneuver (i.e., hard left and hard right steer) at between 56 km/h-80km/h (35-50 mph).

In this crash, the Honda departed the roadway in a clockwise rotation as the driver was steering right and applying hard braking. The vehicle's left side wheels created furrows in the ground as it rotated and traveled toward impact with the woven wire fence. As the rotation increased, the opposing force on the left side wheels continued to build and induced a roll moment, which tripped the vehicle coincident with the fence impact. The vehicle rolled over left side leading 6 quarter turns across a distance of approximately 11 m (36.1 ft). The driver remained restrained in his seat position during the rollover and the vehicle came to rest on its top.

CASE VEHICLE

The 2006 Honda Civic Hybrid CVT was a front wheel drive, 4-door, sedan (VIN: JHMFA35226S------) equipped with a 1.3L, 4-cylinder gasoline engine with permanent-magnet electric motor, a 158 volt sealed Nickel-Metal Hydride (NiMH) propulsion battery, and a continuously variable automatic transmission. The vehicle was also equipped with driver and front right passenger dual stage frontal air bags, side curtain air bags and front seat back-mounted side impact air bags. The front row was equipped with bucket seats, adjustable active head restraints, and lap-and-shoulder belts. The second row was equipped with a bench seat, lap-and-shoulder belts, adjustable head restraints, and Lower Anchors and Tethers for Children (LATCH) in the outboard seating positions. The vehicle was equipped with an electronic odometer and the mileage at the time of the inspection could not be determined. The driver estimated the vehicle's mileage was approximately 64,372 kilometers (40,000 miles). The vehicle's specified wheelbase was 270 cm (106.3 in).

CASE VEHICLE DAMAGE

Exterior Damage: The Honda sustained damage from the penetrating type impact with the fence on the front, left side and top planes (events 1, 2 and 4). The direct damage on the front plane (event 1) involved the front left corner (**Figure 5**) and consisted of scratches on the bumper fascia and headlamp/turn signal assembly. The direct damage began at the front left bumper corner and extended 25 cm (9.8) to the right on the bumper. There was no residual crush as a result of this impact.

The direct damage on the left side plane (event 2, **Figure 1**) consisted primarily of scratches, which began 64 cm (25 in) forward of the left front axle and extended 238 cm (93.7 in) rearward along the left fender, left side doors, and the left roof side rail. While the majority of the damage consisted of scratches from the fence wire, there was a crush pocket on the left sill and left front

door (**Figure 4**) due to engagement with one of the fence posts. The crush pocket began 214 cm (84.3 in) forward of the left rear axle and extended rearward 77 cm (30.3 in). The crush involved primarily the sill and the crush measurements were taken at that level. The maximum residual crush was 5 cm (2 in) occurring at C_3. The table below shows the crush profile for event 2.

Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	2	69	5	77	0	2	5	2	0	0	45	40
in		27.2	2.0	30.3	0.0	0.8	2.0	0.8	0.0	0.0	17.7	15.7

The damage from the rollover (event 3) involved the left side, top, and right side planes (**Figures 1** and **5**). The direct damage on the left side plane overlapped the damage from the fence impact and involved the fender, both doors, roof side rail, and the quarter panel. The direct damage on the right side plane involved the right front door. The direct damage on the top plane involved the hood, and roof. It extended the full width of the roof, 111 cm (43.7 in). The maximum vertical crush was 9 cm (3.5 n), which occurred on the roof 190 cm (74.8 in) rear of the right front axle and 46 cm (18.1 in) left of the right roof side rail. There was no lateral displacement of the roof structure.

The direct damage from the fence that occurred during the rollover (event 4) involved the hood and windshield (**Figure 5**). A small hole was punched in the hood and right portion of the windshield, probably from one of the fence posts. The Honda's wheelbase was unchanged. The induced damage involved the hood, roof, and left quarter panel.

Damage Classification: The Collision Deformation Classifications (CDCs) for the Honda were: **11-FLEE-1** (**320** degrees) and **09-LYAW-2** (**280** degrees) for the front and left side impacts with the fence (events 1 and 2), **00-TYDO-2** for the rollover (event 3), and **00-TYDW-1** for the fence damage on the top plane (event 4), which occurred during the rollover. Impacts with yielding objects such as a fence are out of scope for the WinSMASH program. However, the Barrier algorithm was used to calculate a Barrier Equivalent Speed (BES) for the fence post damage to the left sill (event 2) and the BES was 7 km/h (4 mph). The severity of the damage from the fence impacts for events 1 and 4 were minor based on the extent of the damage. The severity of the damage from the rollover was minor based on the extent of the roof crush.

The vehicle manufacturer's recommended tire size was P195/65R15. The vehicle was equipped with the recommended size tires. The Honda's tire data are shown in the table below.

Tire	*Measured Pressure*		*Vehicle Manufacturer's Recommended Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	Flat	Flat	221	32	5	6	None	No	Yes
LR	207	30	221	32	6	7	None	No	No
RR	186	27	221	32	5	6	None	No	No
RF	490	71*	221	32	5	6	None	No	No

(**Please note that the measured pressure for the right front tire is the actual value and not a typo*)

The inspection of the Ford's interior revealed evidence of occupant contact on the lower left instrument panel, roof, left front door arm rest, and the left side curtain air bag. The lower left instrument panel was slightly deformed due to loading by the driver's left knee. A small scuff was present on the left side curtain air bag, possibly due to contact by the driver's left arm. A scuff was also present on the roof above the driver's seat, possibly due to contact by the driver's head, which would have occurred during the rollover. The left front door arm rest was deformed probably due to contact by the driver's left hip.

The left rear door was jammed closed while the other doors remained closed and operational. All of the window glazing was either closed or fixed. The windshield was in place and cracked due to impact forces while the left front and right front window glazing were disintegrated due to impact forces. There was no evidence of steering rim deformation or compression of the energy absorbing steering column.

There were five vertical intrusions of the passenger compartment. The most severe involved the roof, which intruded 10 cm (3.9 in) and 8 cm (3.1 in) into the front center and front right sectors, respectively. The roof also intruded 3 cm (1.2 in) into the front left sector.

CONFORMANCE WITH FMVSS 305, SECTION 571, ELECTRIC POWERED VEHICLES

The Honda's propulsion battery pack was housed within a sealed metal box (**Figure 6**) located within a metal compartment behind the second row seat back (**Figure 7**). The battery box was completely insulated and electrically isolated from the vehicle body. The battery pack consisted of battery cells, each about the size of a standard D-cell battery. The total voltage of the battery pack was 158 volts. Small quantities of a highly alkaline liquid electrolyte are used in the manufacture of each cell; however, in the finished cell the electrolyte is non-liquid and sealed in a metal case[1].

[1] "Honda Emergency Response Guide for Hybrid Vehicles", 16 April 2009, https://techinfo.honda.com

The cover to the metal compartment, which contained the propulsion battery box and other electrical components, was removed and the components were visually inspected. There was no evidence of damage or movement of the propulsion battery box or any of the components, and no evidence of electrical arcing or melting of any components. A voltage measurement was taken at the junction board terminal of the DC/DC converter, and the voltage reading was zero volts. Other associated high voltage cables, connectors, and components (that were accessible) within the engine compartment (**Figure 8**) were also examined and there was no evidence of damage, electrical arcing, or melting of components.

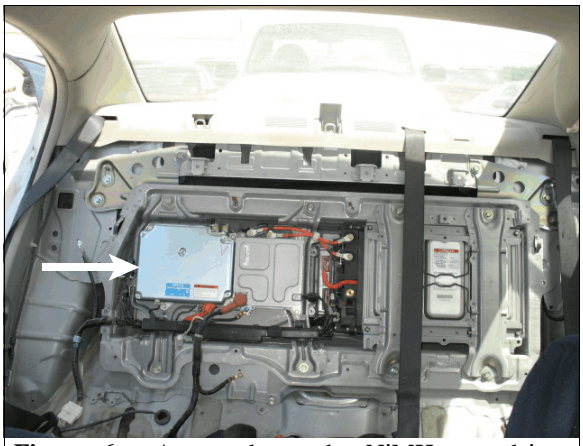


Figure 6: Arrow shows the NiMH propulsion battery box

Figure 7: The metal compartment located behind the second row seat back, which contained the NiMH propulsion battery box

Figure 8: The Honda's engine compartment, arrow shows high voltage cables

AUTOMATIC RESTRAINT SYSTEM

The Honda was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system that consisted of dual stage driver and front right passenger air bags, driver seat position sensor, seat belt usage sensors, retractor and seat belt buckle-mounted pretensioners and a front right passenger weight recognition sensor. The manufacturer has certified that the vehicle is compliant to the Advanced Air Bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208.

The vehicle was also equipped with a front seat back-mounted side impact air bags and roof side rail-mounted side curtain air bags. The vehicle's side impact sensors were located on each side of the vehicle within the lower B and C-pillars. The side curtain air bag inflation cylinders were located within the lower C-pillars.

The Honda's side curtain air bags were located along the roof side rails inside the headliner, and extended from the A-pillar to the C-pillar. The deployed left side curtain air bag (**Figure 9**) was 180 cm (70.9 in) in width and 38 cm (15 in) in height. The air bag was not tethered to the A-pillar or C-pillar. The space between the front of the air bag and the A-pillar was 15 cm (6 in) at the approximate center of the air bag. The air bag was designed with inflation

chambers adjacent to the front left and second row left seat position, and appeared to have a vent port at the front and rear of the air bag. The fold creases on the air bag indicated that it had been folded accordion fashion within the headliner. A possible occupant contact scuff was located 45 cm (17.3 in) rear of the front of the air bag and 7 cm (2.8 in) above the bottom of the air bag.

Figure 9: The front portion of the left side curtain air bag, yellow tape shows a possible occupant contact scuff from the driver's left arm

The driver's seat back-mounted side impact air bag was located in the outboard side of the seat back (**Figure 10**) and deployed through a tear-seam. The deployed air bag was oval and had a single tether where both sides of the air bag were sewn together. The sewn area was 15 cm (5.9 inches) in width and 8 cm (9.4 in) in height, and was located in the center of the air bag. There was also a 5 cm (2 in) diameter vent port located on the outboard side of the air bag. The deployed air bag was 49 cm (19.3 in) in height and 29 cm (11.4 in) in width. Inspection of the air bag revealed no discernable evidence of occupant contact and no damage.

Figure 10: The front left seat back-mounted side impact air bag

The Honda's driver's frontal air bag was located within the steering wheel hub and the front right passenger frontal air bag was located within the top of the right instrument panel. Neither of these air bags deployed during this crash.

MANUAL RESTRAINT SYSTEM

The Honda was equipped with lap-and-shoulder belts in all the seating positions. The front left seat belt was equipped with continuous loop belt webbing, an adjustable upper anchor that was in the full down position, retractor-mounted and buckle-mounted pretensioners, sliding latch plate, and an Emergency Locking Retractor (ELR). The front right seat belt was similarly equipped but had a switchable ELR/Automatic Locking Retractor (ALR). The second row seat belts were similar to the front right seat belt but had fixed upper anchors and were not equipped with pretensioners.

The inspection of the driver's seat belt assembly revealed historical usage scratches on the latch plate. The seat belt webbing also had a slight stretched appearance and the retractor was jammed with a length of belt webbing extended out of the retractor consistent with usage. The buckle-mounted pretensioner did not actuate. The evidence inside the vehicle corroborated the

driver's interview statement that he was restrained in this crash. The remaining seat positions were unoccupied.

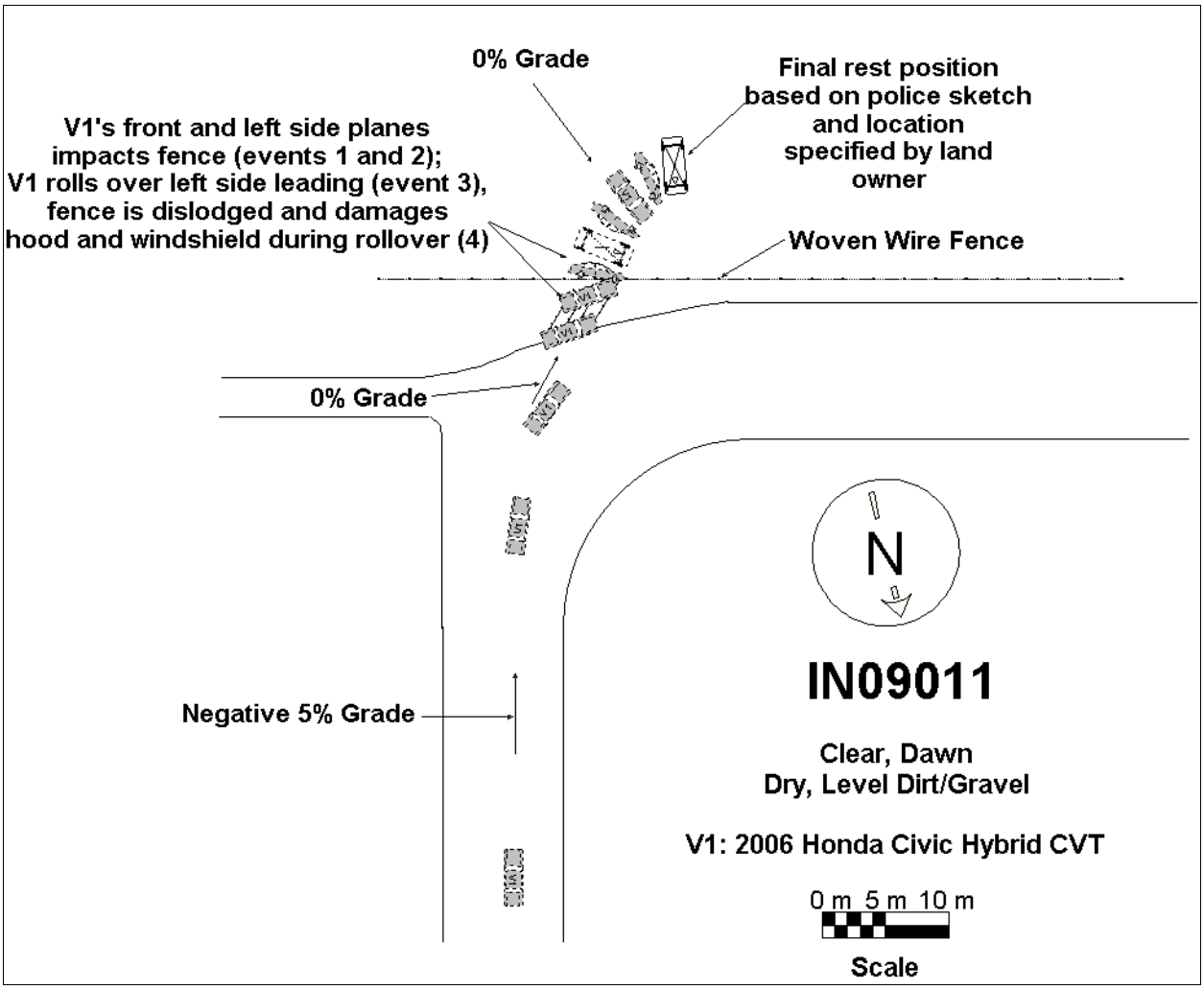
CASE VEHICLE DRIVER KINEMATICS

The Honda's driver [37-year-old, male; 168 cm and 66 kg (66 in, 145 lbs)] was seated in an upright posture with his back against the seat back and both hands on the steering wheel at the 10 and 2 clock positions. The driver's seat track was located between the middle and rear most positions and the seat back was slightly reclined. The top of the adjustable head restraint was located 26 cm (10.2 in) above the top of the seat back. The tilt steering column was located between the center and full down position. The driver was wearing contact lenses.

The driver indicated during the interview that as the vehicle rotated clockwise approaching impact with the fence, he braced with both hands against the steering wheel and applied hard braking with his right foot. He was also leaned to the left to some degree. The driver was displaced to the left and toward the roof during the fence impact and the rollover. While there was no discernable occupant contact evidence on the seat back-mounted side impact air bag, occupant kinematic principles indicate that the left side of his torso loaded the air bag. The driver's head also probably loaded the side curtain air bag and his left arm possibly loaded the side curtain air bag. The driver remained restrained in his seat position as the vehicle rolled over. The scuff on the roof indicated that his head possibly contacted the roof when the vehicle rolled onto its top plane. His left hip also probably loaded and deformed the left front door arm rest.

CASE VEHICLE DRIVER INJURIES

The driver sustained no injuries as a result of this crash and did not seek medical attention.


0% Grade
Final rest position based on police sketch and location specified by land owner
V1's front and left side planes impacts fence (events 1 and 2); V1 rolls over left side leading (event 3), fence is dislodged and damages hood and windshield during rollover (4)
Woven Wire Fence
0% Grade
N
Negative 5% Grade
IN09011
Clear, Dawn
Dry, Level Dirt/Gravel
V1: 2006 Honda Civic Hybrid CVT
0 m 5 m 10 m
Scale